Teaching Statement — Debanjana Kundu

I consider myself fortunate to have learnt mathematics from some of the best teachers. One of the main reasons I wish to pursue a career in academia is so that I can share the under-appreciated beauty of mathematics with others. I have been a part of two education systems, with significantly different philosophies, and I believe this valuable experience will help me adapt to any teaching environment.

A major obstacle in teaching mathematics stems from the fact that most people believe mathematics is a subject meant only for those who are "born with it". *The Telegraph* published an article[1] in 2011, where the opening lines were "Being good at mathematics may be entirely pre-destined—you either have it or you don't". The article cites a paper from the psychology journal *Developmental Science* based on a study conducted at Johns Hopkins University. The idea that math ability is mostly genetic is one dark facet of a larger fallacy that intelligence is mostly genetic. Believing that one can be born dumb, and is doomed to stay that way, is believing a preposterous lie. Mathematical skills are increasingly important for getting good jobs these days—so believing you can not learn math is especially self-destructive. As a mathematician, and as a teacher, my primary goal is to help students move past this mindset.

In my experience, the traditional lecture style often reinforces students' beliefs about needing an innate ability to understand mathematics. They watch an experienced problem solver tackle questions with ease, often without making mistakes, as they arrive at their solutions. Students expect they should have a similar experience while attempting problems. When this does not happen, they quickly become frustrated. I constantly remind my students that everybody struggles with mathematics, including me. But the only way around is by practising. In the words of W. E. Hickson "if at first you don't succeed, try, try again".

Tutorials are crucial to an undergraduate level mathematics course. They reinforce key concepts, provide new perspectives, and create opportunities to work on problems with guidance. The environment tends to be more relaxed as there are fewer students and the tutors themselves are (graduate) students. Students can use this welcoming environment to explore new ideas and to test their understanding of lecture material.

As I look back at my undergraduate years, I realize that I learnt those subjects better where I would get "stuck" often and would talk to my friends to discuss the material with them. I believe that an interactive style of teaching is the most effective one in smaller classes. When asked a question in class, I prefer not to give away the answer immediately. I engage other students in the discussion and try to make them work out the answer to the question. In a regular tutorial, I first introduce a few examples and then give them some time to work on harder problems in small groups. During this time, I discuss the problem with the students and give ideas and/or hints to make sure they are on the right path. To encourage peer learning, I ask for volunteers to present their solutions. Often, the students are shy about presenting their work so I read through their solutions making sure it is correct. Once they know they have the right answer, they are more confident while presenting. This entire process is time consuming and we solve fewer problems in each tutorial, but in my opinion they gain greater knowledge from solving problems with guidance. Whether it is a first year linear algebra course or an upper year advanced number theory course, I think my students go back home knowing that they can tackle hard problems.

Over the years, I have taught Linear Algebra, Calculus, and Multivariable Calculus to non-math majors. I carried my philosophy from these tutorials into my position as an instructor. Unfortunately, most students need to register for these introductory courses because of university mandate and not out of an interest in mathematics. In such courses, I am willing to sacrifice a bit of rigour to make sure they remain enthusiastic till the end. I recall that teaching my first Calculus II course was particularly challenging. This was my first experience of teaching a *flipped classroom*, and it was also the first time I was teaching a class of 200 students. I was upset that even by the end of the course, I did not know the names of my students. What I continue to find extremely challenging in teaching classes that size is some students find the material too easy whereas some others find it too hard. It is very difficult to hit the "Goldilock zone". I took regular (anonymous) feedback from students to make sure that majority of the students were comfortable with the material. I encouraged those who continued to find the material very difficult to come to my office hours.

[1] https://www.telegraph.co.uk/education/educationnews/8693105/People-are-born-bad-at-maths.html

At the end of every lecture, we spent 15 minutes solving problems on Top Hat[2]; the focus was often on the subtle points. This application allowed me to post questions (multiple choice, fill the blank, numeric answer type etc.) which the students could answer in a set amount of time. If the students needed more time, I could add time on the clock and once everyone turned in their answers via the app, I could see how many students got the correct answer. If a significant number of students answered incorrectly, I would encourage them to discuss the problem with fellow students and give them an opportunity to answer the question again. Almost always, this discussion with classmates proved helpful and majority of the students got the correct answer. This helped me prepare for the next lecture, as I had a clearer picture of what concepts the students struggled with the day before. Even though as a student I was never exposed to this style of lecturing, I have come to appreciate this relatively recent learner-centred model of instruction.

Just when I started feeling comfortable teaching large classes, we were hit by COVID-19 and teaching went online, literally overnight. This was a challenge for me, just as it was for everyone else. I co-organized a (multi-section) course on Multi Variable Calculus in Summer 2020. Our goals were modest; we wanted to be *adequate*. With trial and error, I realized that it is hard for students to stare and concentrate at a screen for long intervals of time; so I started teaching in 20-minute bursts followed by a short break. I share my OneNote *notebook* with students to create a *blackboard-like* effect. This allows students to look back at definitions, examples, or notations. I try to make best use of technology, such as using *Breakout Rooms on Zoom*, *Piazza*, virtual study rooms, etc. to encourage students to continue discussing mathematics with friends. It is important to add a *human component* to my teaching, more so now; I encourage students to turn on their cameras at the start and end of class, even if it is just to say hello.

In every endeavour, I make it clear to my students and peers that they are welcome to ask questions, that making mistakes is how you learn and that developing good problem solving skills takes time and effort.

I have (co-)organized a large number of semester-long Learning Seminars involving undergraduate students, graduate students, post-docs and faculty members. The topics have ranged from Trace Formula to Etale Cohomology to Modular Forms and Theory of elliptic curves with complex multiplication. The goal has always been to establish a sense of community, improve our communication skills, and also learn about different areas of number theory not necessarily related to our research.

I have mentored high school students as a part of the Outreach Program[3]. In Winter 2018, I mentored a brilliant 9^{th} grader interested in competitive mathematics. She was particularly interested in Combinatorics and we explored graph theory together. Our ultimate goal was to understand the proof of the Five Colour Theorem. Along the way, I paired her interest in combinatorics with my interest in abstract algebra and introduced her to the group theory behind Rubik's cube. During the program's 2019 iteration, I got an opportunity to mentor an 11^{th} grader who genuinely found high school mathematics boring. The reason for her to join our mentorship program was because she wanted to do "fun" mathematics. I was glad I got to work with her. Apart from solving a large number of geometry and arithmetic puzzles, we explored Benford's Law together. The goal was to understand how it is often used in fraud detection. She was able to find real life applications of mathematics which she thoroughly enjoyed!

In the future, I look forward to developing new courses. I have noticed that most universities don't offer Number Theory courses at the undergraduate level. I believe it is possible to introduce several concepts used in *modern* Number Theory at this level. I would want to bring the courses I teach closer to my area of research and whenever possible introduce students to undergraduate research. In addition to my teaching experience, I have given talks at conferences and seminars about my research. Although these talks are on completely different subjects than what I teach my students, they give me the necessary experience of addressing a large audience. I am determined to pursue a future career in academia and am confident in my ability to adapt to the needs of the department in teaching both undergraduate and graduate courses. I strive to become a better educator who is knowledgeable, competent, and respectful to my students.

[2] http://www.tophat.com
[3] http://mathplus.math.utoronto.ca/home/mentorship